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Full Length Research Paper

Contribution of Legume Intercrop as a Climate Smart Agriculture Practice to Coffee Production among Smallholder Farmers in Kisozi Sub County

Baligeya Stephen*, and Saul Daniel Ddumba

Directorate of Graduate Studies, Research, And Innovations, Busitem University.
*Corresponding Author E-mail: baligeyas@gmail.com +256772584622

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ABSTRACT: This study evaluated the influence of legume intercropping, a climate-smart agricultural strategy, to coffee production among smallholder farmers in Kisozi Sub County. The study utilized a combination of research methods, including a set of well-structured questionnaires and semi-structured interviews with heads of subcounty agricultural extension staff at the Kisozi Sub County level. Using a descriptive research approach, 345 smallholder farmers were interviewed as a sample. The results demonstrated that climatic change has significantly impacted flowering, coffee bean falling, and leaf scorching. The legume intercrop substantially improved soil water retention, protected coffee plants from nitrogen loss, and shielded the soil from running water, among other benefits. This study found that climate change has a variety of consequences on coffee output, including an increased occurrence of drought conditions and, in some circumstances, an increase in rainfall. The study also determined that legume intercrops encourage profit maximization since smallholder farmers may harvest numerous crops at once and supply nitrogen to the soil, which coffee bushes need to feed themselves and produce high-quality beans. It was determined that elderly coffee plants pose the greatest obstacle to legume intercrops for high-quality coffee production. This study advocates promoting the concept of legume intercropping as a suitable smart agriculture strategy in coffee production.

Keywords: Legume Intercropping, climate smart agriculture, coffee production, smallholder farmers

INTRODUCTION

The United States is not one of the world's major coffee producers. In fact, coffee can only be sold commercially in two states: Hawaii and California. However, Puerto Rico, which is a territory of the US, has a thriving coffee industry. Experimental coffee growing projects are also occurring in Georgia and Santa Barbara, California. About 90% of the coffee consumed in the US is an import, especially from South America. The country also imports raw coffee beans, processes them into various coffee products, and then exports them to the international market (Misachi, 2019). However, the drought season that hit some parts and is longer than usual, comes with negative implications for an area where 90% of the coffee production takes place, which requires adopting smart climate agricultural practices that enhance the resilience of production to climate change (Kimmi, 2020). Among the EU Member States, Germany produced the most roasted coffee in 2019 (572 000 tonnes, or 31% of the total EU production), followed by Italy (508 000 tonnes, or 28%), ahead of Spain (143 000 tonnes, 8%), the Netherlands (136 000 tonnes, 7%), France (133 000 tonnes, 7%), and Sweden (91 000 tonnes, 5%) (Eurostat, 2020). However, the coffee sector in Europe faces challenges related to climate change, resulting in low productivity and price volatility. Thus, coffee is relatively unprofitable, and steady smart climate agricultural measures help to enhance coffee production amid abrupt changes in climate (Mienke, 2021).

In many coffee-producing countries like Brazil and Vietnam, coffee grows in open conditions without any shade, coupled with intense cultivation practices aimed at higher productivity (Jesko, 2021). The terrain of coffee areas in these countries is highly amenable to mechanization of farm operations, which brings efficiency. While in India, coffee has been grown under two-tier shades in a more sustainable way for centuries. Coffee does well in undulating terrains of varying gradations, which gives less chance for mechanization (Jesko, 2021).

The Middle East region has been a significant consumer of coffee for many centuries, but there is a recent trend growing thrust for a specialty store in this region (Hammond, 2020). Having more coffee choices and fewer restrictions on selecting the best coffee is helping with the opening of specialty stores in the region. Regional coffee shops could see a significant profit increase by upgrading the quality of coffee, especially considering the increase in consumer behavior towards an appreciation for good-quality coffee and a desire for the sophisticated coffee taste profile that is further helping the coffee market to grow during the forecast period (Hammond, 2020).

Coffee is the most traded commodity in Africa after oil, with an annual turnover exceeding US $10 billion and accounting for an estimated 80% of total foreign currency earnings in some African countries (Neg et al, 2011). Being the origin of Arabica coffee beans and the largest coffee producer in Africa, provides an opportunity to meet the demand for Arabica as it makes up most of the coffee used in specialty stores (Modor, 2021). According to the USDA, Ethiopia supplied 6,943 (1000 MT, 60-kg bags) of Arabica coffee production in 2016-2017 and production will grow due to demand for premium coffee in the market (Modor, 2021).

Over five million people in East Africa are either coffee growers or work in the industry. It is the home to some of the top nations exporting premium coffee in the world, including Ethiopia, Rwanda, and Kenya. However, coffee trading in East Africa can occasionally be challenging because of small farm sizes, inadequate infrastructure, and climatic and political instability (Katie, 2020). from Kenya in 2000 revealed that agricultural products from rural smallholder farmers contributed to export items that produced income and employment possibilities (60 percent of horticultural export, 62% of black tea, and 80% of dairy output) (Thorlakson and Neufeldt, 2012). In 2017, the "majority of (African] countries," particularly the East African nations of Burundi, DR Congo, Rwanda, and Tanzania, experienced severe reductions in production since the early 1990s. It blamed the coffee market's liberalization and falling coffee prices, which were aggravated by war, limited access to resources like as fertilizer and financing to replace plants, and a lack of formal training (Katie, 2020). As a result, smart climate agriculture methods are a vital prerequisite for increasing coffee production. Uganda ranks eighth in the world in terms of coffee output volume, tied with Peru, and second in Africa after Ethiopia. Uganda produces 3-4 million 60-kilogram bags of coffee each year, accounting for only two to three percent of global production and trailing behemoths such as Brazil (55 million bags) and Vietnam (45 million bags) (25 million). Nonetheless, coffee has grown to become Uganda's most important and valuable industry, worth more than $400 million. It accounts for at least 20% of the country's export revenue, and the Uganda Coffee Federation estimates that one in every five Ugandans, or about eight million individuals, obtains the majority or all their income from coffee. Overall, the greatest climatic constraints for coffee production are drought and high heat. Because of documented changes in global climate and because coffee agriculture has moved to marginal lands, where water scarcity and unfavourable temperatures are major restraints to coffee yield, these constraints will become increasingly important in several coffee growing countries (Barry, 2020).

In Uganda, Robusta coffee accounts for 80 percent of overall output, with Arabica coffee accounting for the remaining 20 percent. Robusta coffee predominates because it thrives in low-altitude areas of eastern, central, western, and south-western Uganda. Arabica coffee, on the other hand, can only thrive at altitudes of 1500m and above sea level on the slopes of Mount Elgon, Mount Rwenzori, and Mount Muhabura (Bamwesigye et al., 2015).

The decision to cultivate a cover crop is heavily influenced by the farmer's goals, such as preventing soil erosion, providing fertility, insect control, yield enhancement, and suppressing root-nematodes in cropping systems (Barry, 2020). Intercropping is being promoted as one of the integrated soil fertility management strategies that involves growing two or more crops in the same area at the same time. It has been used for decades and has helped agriculture achieve its goals (Lusembo, Mugisa, Nakyagaba, and Nampeera, 2019).

In addition, intercropping systems are beneficial to smallholder farmers in the low-input and/or high-risk environment, where intercropping of coffee and legumes is widespread among smallholder farmers due to the ability of the legume to contribute to addressing the problem of climate change and declining levels of soil fertility. The principal reasons for smallholder farmers to intercrop with legumes are flexibility, profit maximization, risk minimization, soil conservation and improvement of soil fertility, weed, pest, and disease control, and balanced nutrition (Lusembo *et al.*, 2019).

In Uganda, one of the most important reasons for smallholder farmers to intercrop legumes with coffee is to minimize measures against total crop failures and to get different products to use for their family's food and income (Antle and Ray, 2020). Furthermore, intercropping systems use more efficient growth factors because they capture more radiation, make better use of the available water and nutrients, reduce pests, diseases, and suppress weeds, and favour soil-physical conditions, particularly intercropping cereal, and legume crops, which help maintain and improve soil fertility (Antle and Ray, 2020).

Most researchers believe that the coffee legume intercrop system is beneficial to smallholder farmers in the low-input/high-risk environment of the tropics (Negi et al.2011). Intercropping of coffee and legumes is widespread among smallholder farmers due to the ability of the legume to cope with high temperatures and climate change, soil erosion control with declining levels of soil fertility. The principal reasons for smallholder farmers to intercrop coffee with legumes are flexibility, profit maximization, risk minimization against total crop failure, soil conservation and improvement of soil fertility, weed control, and balanced nutrition (Okoth and Siameto, 2011).

Furthermore, intercropping systems can give higher coffee yields than sole crop yields; greater yield stability; more efficient use of nutrients; better weed control; provision of insurance against total crop failure; and improved coffee quality. Also, crop legume as a sole crop requires a larger area to produce the same yield as a legume in an intercropping system (Obadoni et al., 2010).

The availability of water is one of the most important factors determining productivity in coffee legume intercrop systems. Improvement of water use efficiency in these systems leads to increases in the use of other resources and conserves water largely because of the early high leaf area index and higher leaf area (Matusso and Mucheru-Muna, 2014). Garba reported that the coffee Indigofera legume system was the most efficient in terms of production and water use efficiency. When soil water was not limited, the intercrop was higher than the sole crops. However, under water-limiting conditions, WUEV in the intercrop compared to sole coffee can be higher, resulting in returned growth and reduced yield (Matusso *et al.*, 2014).

Increased nutrient uptake in intercropping systems can occur both spatially and temporally. Spatial nutrient uptake increases through the increasing root mass, while temporal advantages in nutrient uptake occur when crops in an intercropping system have peak nutrient demands at different times (Ndung'u et al., 2005). Also, if the species have different rooting and uptake patterns, more efficient use of available nutrients may occur and there may be higher N-uptake in the intercrop than in monocrops (Reddy and Reddi, 2007). Some studies developed outside the Sub-Saharan Africa region have proven the comparative efficiency of intercrops and monocrops. Vesterager et al. (2008) discovered that intercropping maize and cowpea is beneficial on nitrogen deficient soils. Dahmardeh et al. (2010) reported that coffee Indigofera intercropping increases the amount of nitrogen, phosphorus, and potassium content compared to monocrops of coffee. Despite the beneficial effects of intercropping on cereal crops, it may also accelerate soil nutrient depletion, particularly for phosphorous, due to more efficient use of soil nutrients and higher removal through the harvested crops (Mucheru-Muna, et al., 2010).

The purpose of intercropping between high and low-canopy crops is to improve light interception and hence improve coffee yields planted between sufficiently wider rows of the taller crop. Two factors that affect yield in relation to incident radiation in an intercropping system are the total amount of light intercepted and the efficiency with which intercepted light is converted to dry matter. For instance, Tsubo et al. (2001) reported that the radiation intercepted was higher in coffee bean intercropping than in the sole crop. Tsubo et al. (2003) discovered that legumes intercropped with coffee had a 77 percent higher RUE than sole crop legumes. Mucheru-Muna et al. (2010) reported that the MBILI system increases coffee and legume yields through higher light penetration.

Coffee-legume Intercrop systems control soil erosion by preventing rain drops from hitting the bare soil where they tend to seal surface pores, prevent water from entering the soil, and increase surface runoff (Seran and Brintha, 2010). In the coffee-Indigofera spicata intercropping system, spicata acted as the best cover crop and reduced soil erosion more than the coffee-bean system (Biasutti et al., 2009). In intercrops of taller coffee with short legume crops (Reddy and Reddi, 2007), taller crops act as wind barriers for shorter crops. Similarly, sorghum-cowpea intercropping reduced runoff by 20-30% compared to sorghum as a single crop and by 45-55 % compared to cowpea monoculture. Furthermore, intercropping reduced soil loss by more than 50% when compared to sorghum and cowpea monocultures (Zougmore et al., 2000).

It is often said that traditional intercropping systems are better in weed, pest, and disease control compared to monocrops, but it must be known that intercropping is an almost infinitely variable, and often complex, system in which adverse effects can also occur (Mahipal, Singh, Verma, and Babulal, 2021). Weed growth depends on the competitive ability of the whole crop community, which in intercropping largely depends on the competitive abilities of the component crops and their respective plant populations (Korres and Mehdizadeh, 2020).

Intercropping of cereals and cowpea has been shown to reduce striga infestation significantly, and this was due to the soil cover of cowpea that created unfavorable conditions for striga germination (Korres and Mehdizadeh, 2020). Coffee bean intercropping reduced weed biomass by 50-66 percent in many studies and tests, as did weed suppression in maize and groundnut intercropping (Mahipal et al., 2021).

Objective

The study seeks to establish the relationship between legume intercrop and coffee production among smallholder farmers in Kisozi Sub County, Kamuli District.

MATERIALS AND METHODS

Research design

Claybaugh (2020) defines research design as the overall strategy utilized to carry out research that defines a succinct and logical plan to tackle established research questions through the collection, interpretation, analysis, and discussion of data. This study employed a mixed methods approach. The first part of the study consisted of a series of well-structured questionnaires (for legume intercrop and coffee production) and semi-structured interviews with leaders of subcounty agricultural extension officers at Kisozi Sub County level. Therefore, the researcher applied a descriptive research design. This research design offers the researcher a profile of the relevant aspects of the phenomena of interest from an individual, organizational, and industry-oriented perspective (Kasu, 2019).

Study subject

This study took place in Kisozi Sub County in Kamuli District in the Eastern region of Uganda. Kamuli District is part of the old Busoga region; it borders Kayunga District in the west, Kaberamaido and Soroti Districts in the north, across Lake Kyoga. In the Northeast, the district boarders with Kaliro and Iganga Districts, while in the South, it boarders with Jinja. It is approximately 40 km from Jinja town along the Jinja-Kamuli road. The Kamuli District is largely agrarian, with coffee and sugarcane as the major cash crops grown on small and large scales. Kulika Uganda implemented a four-year coffee sustainability project that promoted legume intercropping as a strategy for climate change adaptation. This is a clear justification for the choice of Kisozi Sub County in Kamuli District for the study.

Study population

According to Shu (2014), a study population is a subset of the target population from which the sample comes. The total number of coffee farmers in this study is 4500, but the sample was drawn from 2508 smallholder coffee farmers in Kisozi Sub County. This number comprises males and females, but the study considered households such that responses came from any gender that was readily available in a household at the time of the study.

Determining sample size

Kibuacha (2021) defines a sample size as a research term used to define the number of individuals included in a research study to represent a population. Among more than five approaches to calculating sample size, this study adopted Taro Yamane's developed in 1967 to determine an appropriate sample size for a given population (Uniproject Materials, 2016). The researcher adopted Yamane's (1967) formula to calculate the ample size as follows:

$n = \frac{N}{1+N(e)^2}$ where n = sample size, N (2508) the total population targeted and e = percentage of error in selecting sample

(5% or 0.05), and 1 is representative of any omissions.

$n = \frac{2508}{1+2508\,(0.05)^2} = \frac{2508}{1+2508 \times 0.0025} = \frac{2508}{1+6.27} = \frac{2508}{7.27} = 344.9 \sim 345$ smallholder coffee farmers.

Therefore, the sample size for 2508 was 345 respondents. These were not inclusive of Kisozi Sub County agricultural extension officers.

Instruments of data collection

Data collection refers to the process of gathering and measuring information on target variables to answer relevant research questions and evaluate outcomes (Quan-Hoang, 2018). In this study, the researcher used questionnaires and interview guides. This is because the study was two-way qualitative and quantitative.

A Questionnaire: In this study, the researcher prepared a set of structured questions for smallholder coffee farmers in Kisozi Sub County. The questionnaire was comprised of various sections, including: respondents' social demographic characteristics; questions on climate change; legume intercrop; and coffee production. The composition of the questionnaire was in such a way that each of the questions about the main study variables was rated on a Linkert scale running from 1-Strongly Disagree, 2-Disagree, 3-Not sure, 4-Agree, and 5-Strongly Agree.

Interview Guide: The interview guide guided the researcher in conducting dialogues with the Kisozi Sub County agricultural extension officer. The researcher held each interview session for a period of not more than 45 minutes. Normally, leaving the last 15 minutes to the top of the hour was to enable the interviewees to make organized programs that would probably start with another hour.

Procedure to data collection

On approval and acceptance of the proposal by supervisors, the researcher defended the proposal and obtained credits that led to the acquisition of an introductory letter to the respondents to conduct research.

The researcher then proceeded to the office of Kisozi Subcounty agricultural extension officer to get permission to conduct the study among smallholder coffee farmers in Kisozi Sub County.

The researcher then spared a day and made meeting appointments with households of smallholder coffee farmers through their local councilors at parish and village levels. Local councilors received and read a copy of an introductory letter from the university, indicating that the study was purely academic.

Data gathering by the questionnaires and interview guides succeeded in obtaining permission as indicated above. The researcher took the initiative to explain all the content specifications of the questionnaire to the smallholder coffee farmers, and where the need arose, the researcher helped the smallholder farmers continue interpreting questions for them. This was so common among households that did not have literate smallholder farmers.

To ensure a high level of returns for questionnaires, the researcher visited each household three times, checking on progress after an interval of two to three days for each check. In-between the periods of checking, the researcher was collecting questionnaires that contained full information.

Data analysis

Data was entered into SPSS spreadsheet for generation of inferential statistics. Data was presented using percentage scores, mean, and standard deviations. Correlation analysis from a bi-variate function was used to determine the relationship between demographic characteristics and coffee production. The level of determining significant results was determined at 0.01 or 0.05 confidence level. The researcher presented findings for objective 2 that required establishing the contribution of legume intercrop as a climate smart agriculture practice on coffee production among smallholder coffee farmers in Kisozi Sub County, Kamuli District. To ensure this, the rating measures were mean and standard deviation for each item. To make the analysis more meaningful and communicative, correlational analysis was used to determine the relationship between legume intercrop and coffee production among smallholder farmers in Kisozi Sub County, Kamuli District. To perform this analysis, individual items for legume intercrop were correlated with individual items for coffee production purposely to determine the specific items under the legume intercrop which explain the dependent variable. The significant correlations were determined at a p-value of 0.01 or 0.05 respectively.

RESULTS AND DISCUSSION

Legume intercrop and coffee production among smallholder farmers

The Effect of legume Intercrop on Coffee production was the second objective of this study. This was established using seven items and results were as indicated in (Table 1). The picture painted by the results in (Table 1) reveals that many smallholder coffee farmers in are still unaware of the benefits of legume intercrops. Only two issues received significant attention. First, results show that smallholder coffee farmers, on average, understand that planting legumes with coffee maximizes profits (Mean = 3.85 > 3.46; standard deviation 1.221.39). Increased yields and improved soil fertility are two of the most frequently mentioned benefits of legume intercropping. A critical examination of the other advantages mentioned reveals that they all support the two overarching advantages mentioned. As a result, the perceived benefit of legume intercropping exists at various levels of the results chain, with the final benefit of increased yields filtering in. Despite the fact that production data from farmers could not be obtained due to poor record keeping, the study found that farmers who practiced legume intercropping were more food secure in line with these findings, Okoth and Siamento (2011) discovered that intercropping of coffee and legumes is common among smallholder farmers due to the legume's ability to withstand high temperatures and climate change, as well as soil erosion control in the face of declining soil fertility. The authors also discovered that the main reasons for smallholder farmers to intercrop coffee with legumes are flexibility, profit maximization, risk minimization against total crop failure, soil conservation and soil fertility improvement, weed control, and balanced nutrition. Furthermore, smallholder farmers in Kisozi Sub County agree that legume intercropping helps to keep water in the soil (Mean = 3.76 > 3.46; standard deviation 1.221.39). One of the most important factors influencing productivity in coffee legume intercrop systems is water availability. Improvements in water use efficiency in these systems lead to increased use of other resources and water conservation, owing to the early high leaf area index and higher leaf area. According to Garba, the coffee Indigofera legume system was the most efficient in terms of production and water use. According to the qualitative data, legume intercropping is the most effective climate change adaptation strategy, as one farmer from Buteme parish explained.

"……..besides the other nutrients legumes put in the soil, the leaves of most legumes have a surface covering potential that helps to maintain soil moisture. Before I started planting beans in my coffee garden, you would go through and see that indeed the soil was dried but now if you pass through my coffee, you may think that it has been raining…….".

During the interview, farmers made more connections between legume intercrop and climate change mitigation. Interviews with key informants (extension workers) revealed that the climate change modifying effect of legume intercrops extends throughout the ecosystem. According to Matusso et al. (2014), when soil water was not limited, coffee cowpea intercropping was higher than sole crops. However, under water-stressed conditions, WUEV in the intercrop can be higher than in sole coffee,

Table 1: Contribution of legume intercrop on coffee production.

Contribution of legume Intercrop on Coffee production	Agree	Not sure	Disagree	Mean	St. Dev.
Legume intercrop controls soil fertility	205(59)%	43(13)%	97(28)%	3.41	1.41
*Legume intercrop promotes profit maximization	228(72)%	42(12)%	55(16)%	3.85	1.22
*Legume intercrop maintains water in the soil	238(69)%	41(12)%	66(19)%	3.76	1.33
Legume intercrop increases on nitrogen in soil	182(53)%	48(14)%	115(33)%	3.23	1.50
Legume intercrop controls soil erosion	204(59)%	43(13)%	98(28)%	3.44	1.44
Legume intercrop controls weeds	181(52)%	51(15)%	113(33)%	3.24	1.46
Legume intercrop controls pests and diseases	187(54)%	57(17)%	101(29)%	3.29	1.41
Average				3.46	1.39

Source: Primary Data from Smallholder coffee farmers in Kisozi Sub County

resulting in returned growth and reduced yield.

Despite the fact that other contributions do not exceed the mean and standard deviation, smallholder farmers' knowledge of the contributions of legume intercrops on coffee production is not limited to these two variables. For example, 59% of smallholder farmers acknowledged that legume intercropping controls soil erosion, and these findings are supported by Barry (2020), who discovered that legume intercropping prevents soil erosion, is a source of fertility, pest suppression, yield enhancement, and root-nematode suppression in cropping systems. As a result of studies like this one broadening the knowledge base, this fact will be grasped by many smallholder coffee farmers and will become a reality toward increasing coffee production. Furthermore, 53% of smallholder farmers in Kisozi Sub County agreed that legumes increase soil nitrogen content (Table 1). This is a critical factor because without adequate nitrogen content, the plant does not receive food and thus coffee beans do not develop properly. Other researchers, such as Dahmardeh et al. (2010), found that coffee Indigofera intercropping increases nitrogen, phosphorus, and potassium content when compared to monocrops of coffee. However, Mucheru-Muna et al. (2010) discovered that, despite the beneficial effects of intercropping on cereal crops, it may also hasten soil nutrient depletion, particularly for phosphorous, due to more efficient use of soil nutrients and higher removal through harvested crops. This balance of arguments points to the realization that smallholder farmers should choose the legume to intercrop with coffee to maximize profit rather than the negative implications. Similarly, 54% of smallholder farmers agreed that legume intercrops control pests and diseases. This is in relation to the findings of a maize study by Dahmardeh et al. (2010), which revealed that the most quoted effect for pests and diseases is that one crop can provide a barrier to the spread of a pest or disease of the other crop. Budworm infestation was higher in sole maize than in maize intercropped with soybean. When maize is intercropped with soybean, the number of corn borer insects in maize is reduced. Soybeans and groundnuts are more effective than common beans at suppressing termite attacks.

Relationship between legume intercrop and coffee production

To determine the contribution of legume intercrop on coffee production, a Pearson correlation analysis was performed for items and significant contributions were established at p-value = 0.01 or 0.05 respectively as indicated in (Table 2). According to Table 2, depending on the elements in the correlation line, legume intercrops affect coffee production either negatively or positively. The ability of legume intercrops to conserve soil fertility has a negative statistical correlation with seasonal income from coffee sales (r = -.185**; p.01), indicating that smallholder coffee farmers have not yet adopted this practice to increase yields and conserve soil fertility, which would increase seasonal income. The opposite is also true: smallholder coffee farmers do not have an interest in considering legume intercrops to preserve soil fertility for better yields if the seasonal income is consistently noted to be low.

Applying inorganic nutrients may help maintain soil fertility over the long term. A more sustainable solution to the issue might be to intercrop with species that can reduce soil erosion and/or use symbiotically fixed nitrogen in place of inorganic sources. These findings are consistent with those of Korres and Mehdizadeh, (2020), who found that a planned legume intercrop approach increases soil fertility with a number of advantages for farmers. The results show that legume intercrops that promote profit maximization also pose a negative statistical relationship with coffee production. Specifically, it has a negative correlation with seasonal income *(r =-.170**; p.01)*. By implication, the seasonal income that smallholder farmers obtain from coffee harvests is not significant enough to be attributed to legume intercrops. Additionally, results of the study indicated that, to some extent, legume intercrop is reported to be a factor in maintaining water and moisture in the soil.

Table 1: Relationship between *legume intercrop and coffee production.*

		Farm Size	Seasonal Income	Harvest at stable climate	Harvest at unstable climate	Gen. Remarks on Coffee Production
Conserve soil fertility	Pearson Correlation	-0.019	-0.185**	0.134*	0.014	0.057
	Sig. (2-tailed)	0.725	0.001	0.012	0.799	0.293
	N	345	345	345	345	345
Promotion of profit maximization	Pearson Correlation	-0.090	-0.170**	0.014	0.040	0.076
	Sig. (2-tailed)	0.096	0.002	0.793	0.459	0.159
	N	345	345	345	345	345
Maintaining water in the soil	Pearson Correlation	0.226**	0.316**	-0.123*	0.048	-0.167**
	Sig. (2-tailed)	0.000	0.000	0.022	0.369	0.002
	N	345	345	345	345	345
Increase on nitrogen in soil	Pearson Correlation	0.329**	0.332**	0.030	-0.290**	0.016
	Sig. (2-tailed)	0.000	0.000	0.583	0.000	0.771
	N	345	345	345	345	345
Control of soil erosion	Pearson Correlation	0.344**	.386**	0.007	-0.354**	0.024
	Sig. (2-tailed)	0.000	0.000	0.899	0.000	0.664
	N	345	345	345	345	345
Control of weeds	Pearson Correlation	0.307**	0.180**	-0.092	-0.094	-0.111*
	Sig. (2-tailed)	0.000	0.001	0.091	0.084	0.040
	N	342	342	342	342	342
Control of pests and diseases	Pearson Correlation	0.282**	0.325**	-0.178**	-0.108*	-0.160**
	Sig. (2-tailed)	0.000	0.000	0.001	0.045	0.003
	N	345	345	345	345	345

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

According to Table 2, maintaining water in the soil due to legume intercrop increases coffee farm land size (r =.226**; p.01) and seasonal income (r = -.316**; p.01). coffee farmers who practice legume intercrop maintain water in the soil and register an increase in seasonal income from coffee sales because of cultivating a large piece of land with positive optimism through legume intercrop. Smallholder farmers should, thus, embark on legume intercropping on a large piece of land for increased seasonal income from coffee sales. These results can be married with Lusemb et al., (2019) indicating that through legume intercrop, water is maintained in real amounts in the soil and crop growth becomes less worrying regardless of whether it is rainy or sunny season.

Similarly, increasing nitrogen in soil through legume intercropping contributes statistically significantly to coffee farm size (r =.329**; p.01) and seasonal income (r =.332**; p.01). By implication, smallholder farmers who use legume intercrop and discover that it increases nitrogen in the soil, increase the size of their coffee farm by 32.9%, which in turn brings about a positive return on coffee production at a 33.2% increase. Technically, the key benefits of legumes include the biological fixation of atmospheric nitrogen through a symbiotic relationship with soil bacteria collectively referred to as rhizobia. Furthermore, legumes play an important role in reducing greenhouse gas emissions due to their ability to fix dinitrogen (N2), which would replace fossil-energy-based fertilizers, as well as carbon sequestration and biomass production. However, the positive results are accompanied by some negative findings, specifically that an increase in nitrogen negatively correlates with harvest in an unstable climate (r = -.290**; p.01).

In other words, as Hammond (2020) points out, even if legume intercrops increase nitrogen in the soil, an unstable climate may derail efforts to increase seasonal coffee harvests. If a smallholder farmer uses the legume intercrop approach but experiences drought or flood conditions, the drought causes mineral leaching, while floods erode the top fertile layer of the soil and may also cause leaching, resulting in low harvests during unstable climate conditions.

From Table 2 still, legume intercrop controls soil erosion and this positively correlates with coffee farm size *(r =.344**; p .01)* and seasonal income from coffee harvests *(r =.386**; p .01)*. The implication here is that smallholder coffee farmers who establish that legume intercrop controls soil erosion increases the size of their coffee farms with seasons, and this in turn brings about more harvests due to the increased farm size and, thus, positive implications on seasonal income from coffee sales. More specifically, control of soil erosion through use of legume intercrop brings about 34.4% of the increase in coffee farm size and leads to a 38.6% increase in the seasonal income from coffee sales, which consolidates the relevancy of legume intercrop as far as coffee production is concerned.

According to the findings of Dahmardeh et al. (2010), a legume intercropping system capable of controlling soil erosion and the associated nutrient export while increasing crop yield is an ecologically sustainable strategy required for restoring the impoverished soil productivity in smallholder potato farms. On the negative side, control of soil erosion through legume intercrop interferes with smallholder farmers' positive harvest expectations in unstable climate conditions (r = -.354**; p.01). As a result, even if soil erosion is controlled through legume intercrop, there is still a 35.4% reduction in coffee harvests under unstable climate conditions.

This means that high temperatures or excessive rainfall can still cause soil erosion or nutrient leaching, rendering legume intercrop irrelevant. Legume intercrop was also found to enhance control of weeds, which in turn has a positive correlation with farm size *(r =.307**; p .01)* and seasonal income *(r =.180**; p .01)*. These are positive and significant results, which imply that since control of weeds means that a smallholder coffee farmer will plant more legumes and reduce the task of weeding, they will eventually increase their coffee farm size by 30.7% and, in turn, register an 18% increase in seasonal coffee harvests. In the same vein, control of pests and diseases through legume intercrops poses a positive statistically significant contribution to farm size *(r =.282**; p .01)* and seasonal income *(r =.325**; p .01)*.

According to Bamwesigye et al. (2015), the presence of associated plants in the intercrop can lead to attack escape in three ways, all of which involve the attacking organism's population growth rate being slowed. In one case, the associates cause plants of the attacked component to be less good hosts; in another, they directly interfere with the attacker's activities; and in the third, they alter the environment in the intercrop so that natural enemies of the attacker are favored.

Conclusion

Many smallholder coffee farmers in Kisozi Sub County are unaware of the numerous ways legume intercrops contribute to coffee production. The advantages of using legumes with coffee were widely cited, including increased soil fertility and yields. The analysis of the other provided benefits all supports the two dominant benefits mentioned. Through interviews with a subset of key informants, researchers discovered that legume intercrops have an ecosystem-wide impact on climate change (extension workers). Corn borer insects were reduced when soybeans were intercropped with maize. Common beans are less effective at repelling termites than soybeans and peanuts.

Recommendations

The community must become more resilient to climate change immediately, and so must the government. Due to the numerous advantages that legumes offer smallholder farmers, they should incorporate them as an intercrop in coffee production to better manage their coffee plantations and agricultural methods.

For farmers to improve their farming practices, the government should offer more agricultural assistance services. This can be accomplished by improving the agricultural extension services provided to the public, particularly through training farmers on climate change effects and mitigation strategies, the value of legumes in reducing climate change effects, and the accessibility and provision of inputs (seed), particularly the pertinent leguminous crops for use as intercrops in coffee plantations.

In the Kamuli district, only one sub-county that grows coffee was the subject of this study. Other districts should be the subject of a similar study, and where the impacts and perceptions of climate change vary, case-by-case mitigation methods should be developed. To increase the resilience of rural farmers by introducing legumes as an intercrop in coffee production, local government and the community should be given the authority to execute climate change policies in Kisozi Sub County.

REFERENCES

Antle, J. M., and Ray, s. (2020). Sustainable Agricultural Development An. Economic Perspective. In Palgrave Studies in Agricultural Economics and Food Policy; Christopher, B., Ed.; Cornell University: Ithaca, NY, USA, 2020. *Springer Link, 3*(6), 123-134. Retrieved September 16, 2021, from https://link.springer.com

Bamwesigye, D., Pomazalová, N., and Tamáš, V. (2015). Socioeconomic development in context of economic changes in commodity chain of cofeee in uganda, east african region. Paper presented at the ICABR 2015. *International Conference on Applied Business Research*, 14-17.

Barry, P. (2020). Cover Crops: Types And Benefits To Use In Agriculture. *mountain Research and Development*, 307-312.

Biasutti, M., Sobel, A. H., and Camargo, S. J. (2009). The role of the sahara low in summertime sahel rainfall variability and change in the cmip3 models. *Journal of Climate*, 5755-5771.

Claybaugh, Z. (2020). Research Guides: Organizing Academic Research Papers: Types of Research Designs. *library.sacredheart.edu.*, 10-28.

Dahmardeh, M., Ghanbari, A., Syahsar, B., and Ramrodi, M. (2010). The role of intercropping maize (zea mays l.) and cowpea (vigna unguiculata l.) on yield and soil chemical properties. *African Journal of Agricultural Research*, 631-636.

Eurostat. (2020). Some Statistics for Coffee Time in European member states. *Eurostat*.
Hammond, J. (2020). Saudi coffee farmers chart new path for native brew: These Middle East producers are fighting both climate change and the lure of modernity to preserve a centuries-old way of life. *Zenger*, 32.
Jesko, J. (2021). Celebrating 20 Years of ICP: The importance of humanistic values and entrepreneurship in smallholder coffee farmer support. *20 years, international coffee partners*, 3-7.
Kasu, J. S. (2019). Research Design and Methodology. *IntechOpen Journal*, 19-23. doi:10.5772/intechopen.85731
Katie, G. (2020). Tackling The Challenges of Trading Coffee in East Africa. *perfectdailyground*, 13.
Kibuacha, F. (2021). How to Determine Sample Size for a Research Study. *GeoPoll*, 23-26.
Kimmi, V. (2020). Climate Change is Coming for Your Coffee. *Johnson Hopkins*, 2-4.
Korres, N. E., and Mehdizadeh, M. (2020). Agronomic Weed Control: A Trustworthy Approach for Sustainable Weed Management: Development of an Integrated Weed-Management System. *Science Direct*, 12-25.
Lusembo, P., Mugisa, I., Nakyagaba, W., and Nampeera, M. (2019). Potential Role of Cereal-Legume Intercropping Systems in Integrated Soil Fertility Management in Small holder Farming Systems of Sub-Saharan Africa. *Food and Agricultural Organization Journal*, 24-28.
Mahipal, D., Singh, R. P., Verma, B. L., and Babulal, C. (2021, March 25). Effects of Different Maize–Soybean Intercropping Patterns on Yield Attributes, Yield and B: C Ratio. *International Journal of Plant and Soil Science, 33*(12), 51-58. doi:10.9734/IJPSS/2021/v33i1230486
Matusso, J., and Mucheru-Muna, J. M. (2014). Potential role of cereal-legume intercropping systems in integrated soil fertility management in smallholder farming systems of sub-saharan africa. *Research Journal of Agriculture and Environmental Manage*, 10.
Mienke, S. (2021). German Ministry put coffee at the top of their sustainability agenda. *Ids-Sustainable Trade Initiative*, 13-16.
Misachi, J. (2019). Which States Grow Coffee? Coffee Production In The US. *World Atlas*, 13-17.
Modor, I. (2021). Middle East and Africa coffee market - growth, trends, COVID-19 impact, and forecasts (2021 - 2026). *Modor Itelligence*, 4-8.
Mucheru-Muna, M., Pypers, P., Mugendi, D., Kung'u, J., Mugwe, J., Merckx, R., and Vanlauwe, B. (2010). A staggered maize–legume intercrop arrangement robustly increases crop yields and economic returns in the highlands of central kenya. *Field Crops Research*, 124.
Ndung'u, K. W., Kwambai, T., Barkutwo, J., Wanjekeche, E., Mulati, J., Nyambati, E., and Kifuko, M. (2005). *Effect of different spatial arrangements on yield of maize and different bean varieties in north rift kenya.* Nairobi: Unpublished paper.
Negi, V. S., Maikhuri, R., and Rawat, L. (2011, 3 2). Non-timber forest products (ntfps): A viable option for biodiversity conservation and livelihood enhancement in central himalaya. Biodiversity and Conservation. *World Environment Dissemination Journal*, 545-559.
Obadoni, B., Mensah, J., and Emua, S. (2010). Productivity of intercropping systems using amaranthus cruentus l. And abelmoschus esculentus (moench) in edo state, nigeria. *World rural observations*, 31-37.
Okoth, S. A., and Siameto, E. (2011). Evaluation of selected soil fertility management interventions for suppression of fusarium spp. In a maize and beans intercrop. Tropical and Subtropical Agroecosystems. *Research and Eco-system Journal*, 73-80.
Quan-Hoang, V. (2018). *Data Collection and Analysis.* New York: Prentice hall Publishers.
Reddy, T. Y., and Reddi, G. H. (2007). Principles of agronomy. India. *Kalyam Publishers*, 2-7.
Seran, T. H., and Brintha, I. (2010). Review on maize based intercropping. *Journal of agronomy*, 135-145.
Shu, H. (2014). Encyclopedia of Quality of Life and Well-Being Research. *Springer Link*, 1-3. doi:doi.org/10.1007/978-94-007-0753-5_2893.
Thorlakson, T., and Neufeldt, H. (2012). *Reducing subsistence farmers' vulnerability to climate change: evaluating the potential contributions of agroforestry in western Kenya.* Nairobi: Agriculture and Food Security.
Tsubo, M., Mukhala, E., Ogindo, H., and Walker, S. (2003). Productivity of maize-bean intercropping in a semi-arid region of south africa. *Lockera*, 381-388.
Uniproject Materials. (2016). How to calculate Sample Size using Taro Yamane Method. *Uniproject Materials*.
Vesterager, J. M., Nielsen, N. E., and Høgh-Jensen, H. (2008). Effects of cropping history and phosphorus source on yield and nitrogen fixation in sole and intercropped cowpea–maize systems. Nutrient Cycling in Agroecosystems. *MNH*, 61-73.
Zougmore, R., Kambou, F., Ouattara, K., and Guillobez, S. (2000). Sorghum-cowpea intercropping: An effective technique against runoff and soil erosion in the sahel (saria, burkina faso). *Arid Soil Research and Rehabilitation*, 329-342.